Attachment 2

Institute for Energy Economics and Financial Analysis

Fossil Fuels Fail Reliability Test

Forced Outages During a December Freeze Underscore Serious Performance Problems Facing Coal- and Gas-Fired Electric Generators

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Key Findings

More than 100,000 megawatts of coal- and gas-fired generation failed to start or were forced offline during the Arctic blast that hit the central and eastern U.S. just before Christmas.

December outages stressed utilities across the Eastern Interconnection and forced unprecedented rolling blackouts at two major utilities.

Highly accurate forecasting, together with the rapid growth of battery storage, can help to smooth the gaps in wind and solar variability to prevent outages.

The problems encountered across the central and eastern U.S. during Winter Storm Elliott show that it is time for a more honest discussion about the reliability of the nation's fossil fuel-fired electric generation resources.

Executive Summary

Coal- and gas-fired electric generators are not nearly as reliable as their proponents claim. During the peak of an Arctic blast in the central and eastern U.S. on Dec. 23-24, more than 100,000 megawatts (MW) of coal- and gas-fired generation were offline due to the cold associated with Winter Storm Elliott, highlighting serious performance problems for fossil fuel generators. The outages stressed the entire Eastern Interconnection of the U.S. electricity system and prompted first-of-a-kind rolling blackouts by the Tennessee Valley Authority (TVA) and Duke Energy. In PJM, the nation's largest electricity market, the failure to honor reliability commitments may cost coal and gas plant owners as much as $2 billion in penalties.

A Fossil Fuel Fiasco

- More than 100,000 megawatts of coal- and gas-fired generation failed to start or were forced offline during the Arctic blast that hit the central and eastern U.S. just before Christmas.
- These outages stressed utilities across the Eastern Interconnection and forced unprecedented rolling blackouts at two major utilities.

This report examines the problems that surfaced during the freeze, paying particular attention to the unreliability exhibited by coal and gas generators in five hard-hit areas: the Electric Reliability Council of Texas (ERCOT), the operator of the grid supplying 90 percent of the electricity in Texas; the Midcontinent Independent System Operator (MISO) which serves 15 states as well as the Canadian province of Manitoba; PJM, which supplies power from New Jersey to Illinois; TVA, which serves 10 million people in its seven-state territory; and Duke Energy's North Carolina service territory, served by Duke Energy Carolinas and Duke Energy Progress.

> **Quite frankly … generator forced outages were unacceptable.**
>
> **- PJM's Mike Bryson**

Fossil fuel generation outages occurred everywhere. In PJM, more than 32,500MW of gas and 7,600MW of coal capacity were offline at the height of the cold, despite the substantial capacity payments PJM pays generators to be available at critical times. MISO, which has significantly less total installed generation than PJM, fared almost as poorly. A total of 37,000MW of its coal and gas capacity were offline at the peak. In ERCOT, more than 14,000MW of thermal resources were offline during the storm's peak, even though the state directed generators to better winterize their generation plants in the wake of Winter Storm Uri in 2021. The two individual utilities also reported significant problems. TVA counted roughly 8,000MW of coal and gas that were offline during the height of the event, including its largest coal plant, the 2,470MW Cumberland facility. Duke said almost 4,000MW of its fossil generation were unavailable when needed.

The scope of the problems prompted the Federal Energy Regulatory Commission (FERC) and the North American Electric Reliability Corporation (NERC), the organization responsible for overall grid safety and reliability, to launch a joint inquiry into the events surrounding the December freeze and the performance of the nation's bulk power system. While that review is just starting, FERC approved two winter reliability standards in February that had been proposed by NERC in the wake of the 2021 storm.

The new standards, FERC said, include "generator freeze protection measures, enhanced cold weather preparedness plans, identification of freeze-sensitive equipment in generators, corrective actions for when equipment freeze issues occur, annual training for generator maintenance and operations personnel, and procedures to improve the coordination of load reduction measures during a grid emergency."[1]

Even as it adopted these post-2021 standards, however, FERC also directed NERC to come back to the commission with better winter reliability standards, clearly a recognition that there are still gaps. The concerns were underscored by Commissioner Allison Clements: "There are good measures in these standards, but the requirements for generators to winterize are, to be frank, not up to the severity and gravity of the problems we're facing. We must do better."[2]

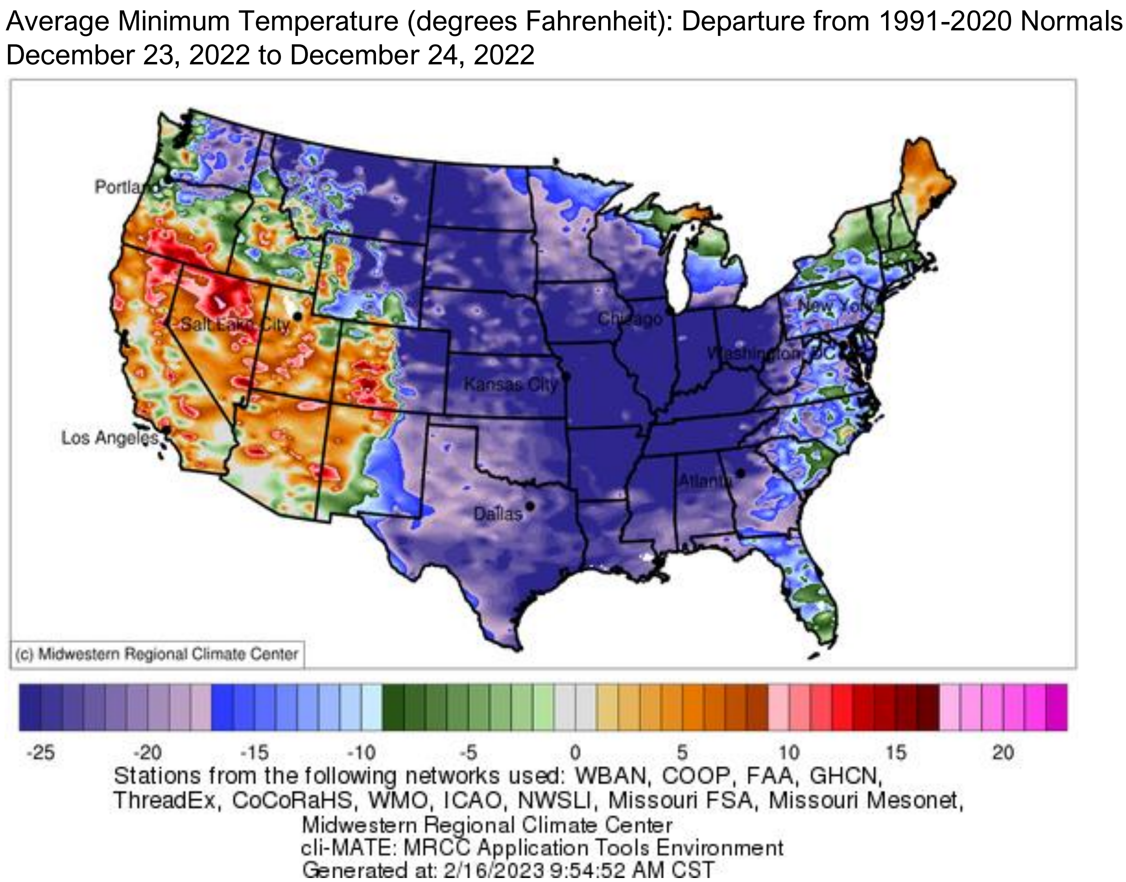
Clearly, it is time for a different conversation regarding fossil fuel generation's reliability, particularly in cold weather.

Gas- and coal-fired power plants can be reliable, but simply assuming they will be available and dispatchable because they are gas- and coal-fueled is no longer a tenable proposition, although that remains a prevalent belief. In a Tennessee House of Representatives hearing examining the problems at TVA, Greg Henrich, a utility vice president, told legislators that when it calculates its reserves, "we assume all of our [thermal] plants are capable of 100% output."[3] Similarly, in its winter capacity assessment, ERCOT said 94% of its thermal generating resources would be available. The optimistic fossil forecasts were egregiously incorrect, and the widespread and repeated outages show it is time for a more accurate assessment of thermal reliability.

[1] FERC. FERC Approves Extreme Cold Weather Reliability Standards, Directs Improvements. February 16, 2023.
[2] Twitter. Allison Clements. February 26, 2023
[3] Tennessee General Assembly, Business and Utilities Subcommittee. House Hearing Room III, Cordell Hull Building. February 7, 2023.

Fossil fuel proponents have long derided wind and solar generation as resources that cannot be relied upon to deliver power on an as-needed basis. But highly accurate forecasting, together with the rapid growth of battery storage, has already significantly undercut criticism, helping to smooth the gaps in wind and solar's predictable variability. And now, with fossil fuel generation proving increasingly unreliable at critical times, it is time for an honest reassessment of how to operate the nation's electric grid reliably.

Figure 1: The Cold Spread Across the Eastern U.S.



Source: Midwestern Regional Climate Center, Purdue University.

The Cold Moves Into MISO

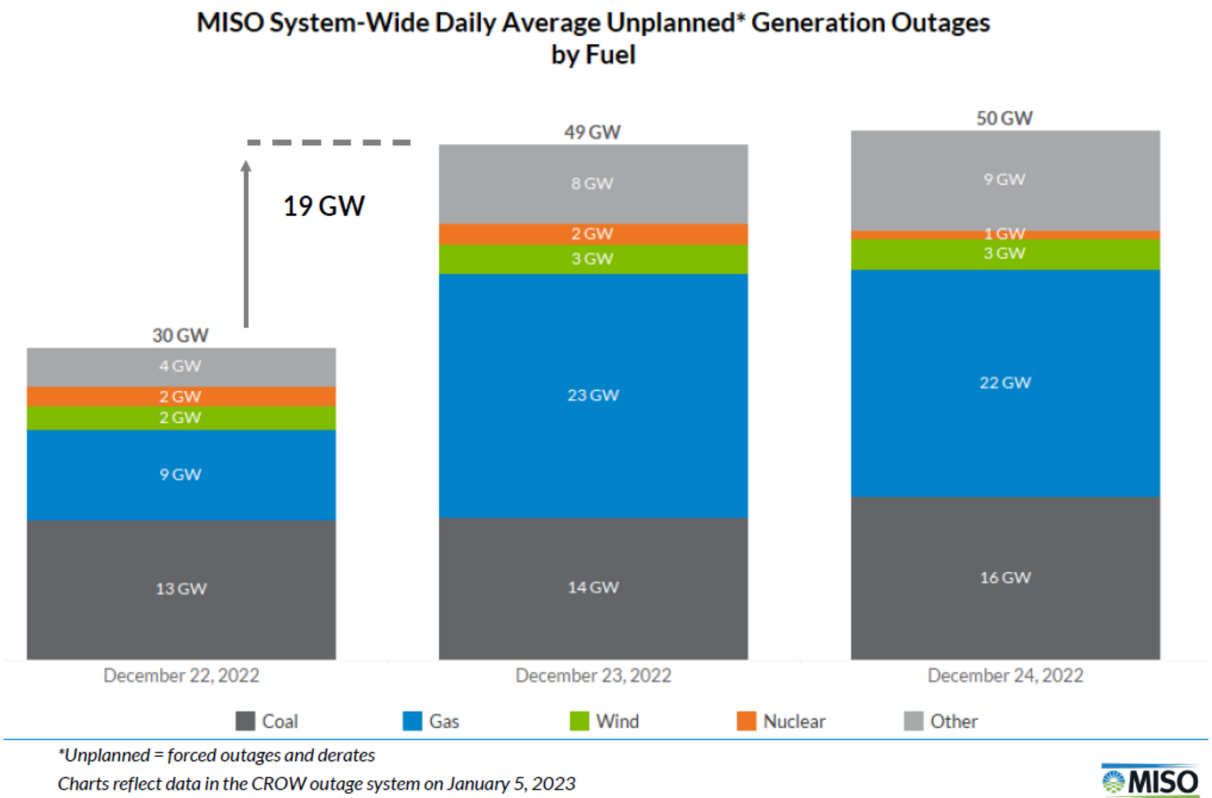
MISO was the first system hit by the storm, with the cold air pouring in during the early morning hours of Dec. 23. From a system-wide load of about 91,000MW at 2 a.m., demand climbed to 105,000MW at 10 a.m. Demand then fell somewhat during the day before, jumping 5,000MW in roughly three hours in the late afternoon, and peaking at 107,000MW at approximately 7 p.m. By comparison, the system-wide peak during Winter Storm Uri in 2021 was 103,000MW.

As demand rose, so did the system's forced outages, particularly among its coal- and gas-fired power plants. On Dec. 22, forced outages in MISO totaled 30,000MW, with 22,000MW coming from coal and gas plants. The next day, the system's forced outages jumped to 49,000MW, with 37,000MW of the outages coming from coal and gas plants— 75% of the generation that was unavailable during that critical period.

The system was able to meet demand throughout the event without any power interruptions, but operators were forced to institute emergency procedures to secure maximum generation and enable access to demand response resources. The measures were needed, MISO said, as a result of "higher-than-forecast system-wide loads, forced outages driven primarily by fuel supply issues and units that failed to start."[4]

[4] MISO. Operations Report. February 13, 2023.

Figure 2: Unplanned Gas, Coal Outages Topped 37GW



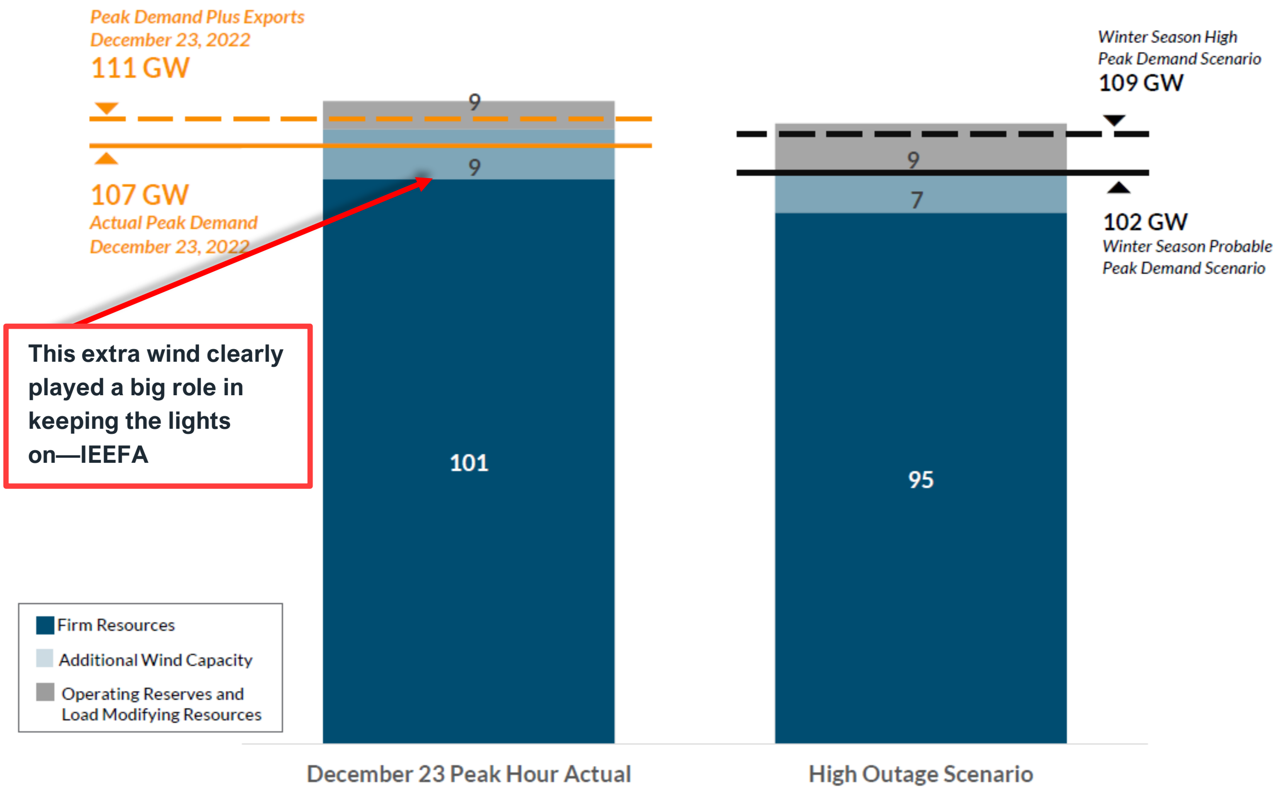
Source: MISO.

One of the key sources of power that kept the system running without the need for customer curtailments was strong wind generation. Systemwide output climbed past 15,000MW at 1 a.m. on Dec. 22 and stayed above that level through 7 a.m. Christmas morning, well after the worst of the cold had passed to the East.[5] During the system's peak generation hour, when output hit 109,888MW, wind generation was 19,965MW.

That wind generation allowed MISO to continue its exports to neighboring utilities and system operators, helping them weather the storm. According to MISO's initial analysis, it exported as much as 5 gigawatts (GW).[6] One of the main export destinations was TVA, which received as much as 1.1GW during the event, a lifeline that clearly mitigated the load shedding required at the utility.

[5] EIA. Hourly Grid Monitor. Accessed February 15, 2023.
[6] MISO, *op. cit.*

Figure 3: Strong Wind Generation Helped MISO, Neighboring Systems



Source: MISO.

ERCOT Encounters More Coal, Gas Plant Outages

In the aftermath of Winter Storm Uri in 2021, Texas enacted regulations requiring generators to winterize their facilities to prevent a repeat of the storm's devastating freeze, which led to at least 246 deaths across the state. In January 2022, ERCOT reported that 321 of the 324 facilities inspected had fully complied with the new rules from the Public Utility Commission of Texas. At the time, Brad Jones, ERCOT's CEO, said: "The Texas electric grid is more prepared for winter operations than ever before."[7]

The December 2022 freeze that engulfed Texas showed just how wrong that statement was.

The cold filtered in beginning on Dec. 22, increasing demand from roughly 45,000MW at 4 a.m. to 73,658MW by 10 p.m., driven by temperatures that fell from the day's high of 45 degrees in Dallas at 4:30 a.m. to just 12 degrees that night. At that point, ERCOT was reporting forced thermal capacity outages of approximately 6,400MW.

By 8 a.m. on the morning of Dec. 23, however, the situation had deteriorated significantly. Demand had climbed slightly overnight, rising to the storm's peak of 73,910MW, but thermal outages had more than doubled, to 14,204MW, pushing operators to take emergency actions.

The thermal outages amounted to 23.3% of the expected coal and gas capacity, all of which had been certified as winter-ready.

One of the most glaring outages was at the newly built Topaz gas-fired facility in Galveston County. The plant consists of 10 identical LM6000 aeroderivative gas turbines and has a total generating capacity of 480MW, according to developer WattBridge Energy LLC, a subsidiary of privately held ProEnergy Services.

When WattBridge was developing the facility in 2021, the company's president told state legislators of the vital need for reliability standards in Texas and warned about the problems posed by renewable power generation. At a 2021 hearing before the Texas Senate Committee on Business and Commerce, Mike Alvarado, the company's president, said: "We think intermittency is the fundamental problem with the grid…. [O]ur business ensures…that Texas homes have reliable access to power during peak demand times, even those with extreme temperatures."[8]

The problem is, when the cold weather showed up in December, a number of WattBridge's gas-fired peaker plants failed their reliability test. The worst performer was the company's newest, the Topaz facility. All 10 of its peakers went offline at 4:05 AM, according to ERCOT's forced outage data, and

[7] ERCOT. Final Winterization Report: Texas Grid Ready for Winter Weather Operations. January 18, 2022.
[8] The Texas Senate. Committee on Business and Commerce Hearing. September 28, 2021.

didn't return to service until after the system hit its peak load at 8 a.m. The company also experienced outages at its H.O. Clarke and Mark One peaker facilities.

WattBridge didn't identify the plants' problems, describing the causes as "other" in its required forced outage filing with ERCOT. However, other operators acknowledged that the cold weather was a factor in their outages, even though they had previously certified their facilities as being winterized. For example, Brazos Electric Power Cooperative, which was hit particularly hard by the 2021 storm, reported that one of the two units at its Jack County combined cycle gas plant was offline during the Dec. 23 morning peak, taking 530MW off the grid.

Fuel availability was also an issue, sidelining a number of gas plants. This issue is discussed at greater length starting on page 21 "Natural Gas Suppliers Stumble."

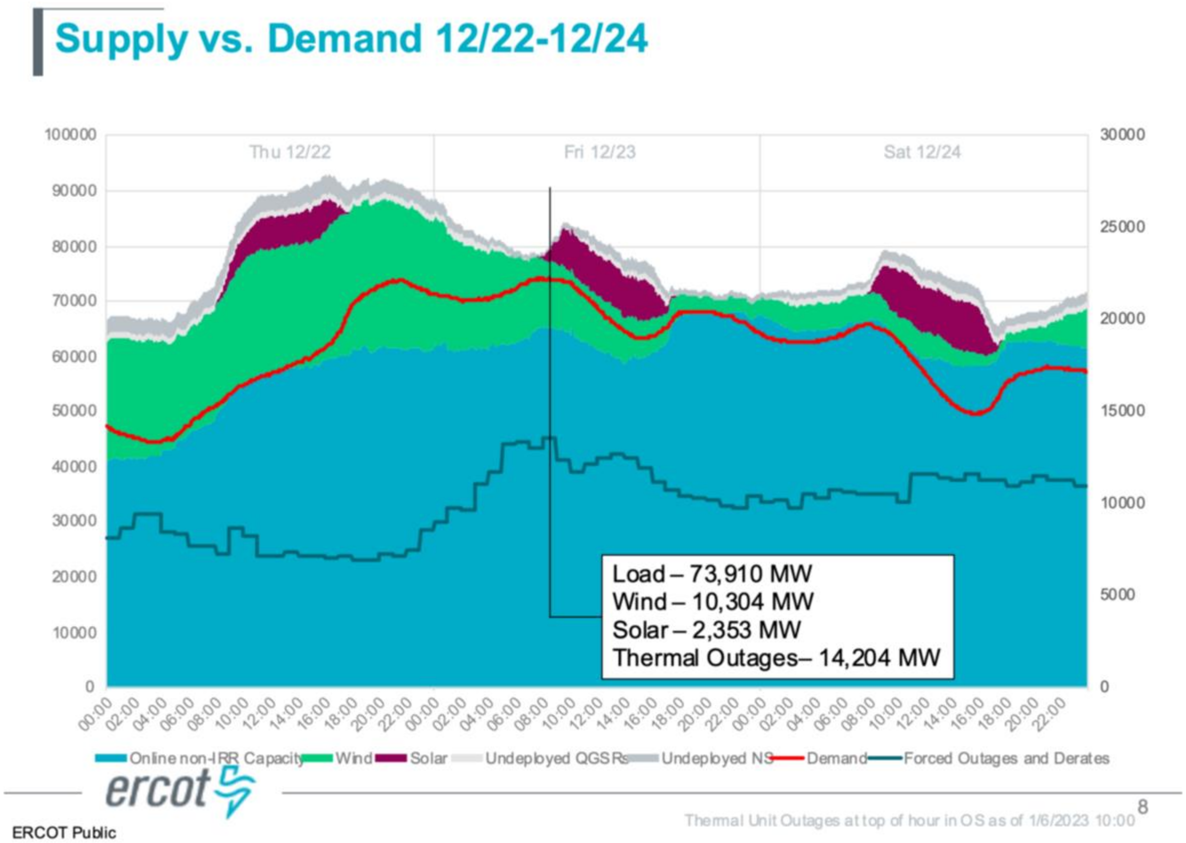
ERCOT's coal-fired power plants didn't fare much better than its gas generators. The worst-performer by far was NRG's four-unit W.A. Parish facility south of Houston. Unit 8, which has 610MW of capacity, was already offline coming into the event because of a May fire, and each of the other three units also had problems during the freeze that forced them offline for varying periods of time. For example, Unit 7, totaling 477MW, tripped offline at 4:15 a.m. Dec. 23, just hours before the system's peak; it didn't return to service until later that evening. Similarly, operators were forced to cut production at the 664MW Unit 5 by two-thirds on Dec. 21 due to exhaust problems; that unit didn't return to service until Dec. 28, well after the event had ended. Finally, production at the 663MW Unit 6 gradually declined during the freeze until the entire unit went offline in the afternoon of Dec. 23.

But the problems at Parish were not unique. Unit 1 at the three-unit, 2,455MW Martin Lake coal plant went offline at 7:45 a.m., just minutes before the system's peak. The 815MW unit returned to service about 80 minutes later, but it had missed the period when it was most needed.

In sum, this is not a reliability record for coal and gas unit owners to crow about.

At the same time, wind generation in the state during the event was well above ERCOT's planning expectations. The system's winter capacity report projected that wind would contribute just under 9,000MW of generation during the season. But wind output during the event climbed above 20,000MW at 10 a.m. on Dec. 22 and remained above that level until early on Dec. 23, allowing the system to easily meet the day's peak. Generation declined on Dec. 23, but was still more than 10,000MW when ERCOT hit its peak for the event. Solar also performed well, producing 2,353MW during the early morning peak, more than the expected amount of just 1,529MW. ERCOT's solar generation later rose quickly, jumping above 7,000MW in two hours, easing the strain on the system's thermal generation.

Figure 4: Thermal Outages Peaked Alongside System Demand



Source: ERCOT.

‘Unacceptable’ Fossil Fuel Outages at PJM

The winter cold got operators’ attention at PJM early on; the system issued its first cold weather alert on Dec. 20, telling generators to prepare and to update PJM with any known operational limitations linked to the coming cold. As it planned for colder temperatures, PJM directed 155,750MW of capacity to be ready to operate. Compared to its load forecast of 126,968MW, operators expected to have 29GW of reserve capacity.[9]

But that cushion evaporated quickly. When operators began calling plants into service, many simply failed to appear, often with no warning. At the beginning of Dec. 23, about 12,000MW of capacity was offline across PJM; by the end of the day, the total had jumped to 34,500MW and it continued rising through the night and into the morning of Dec. 24. The outages peaked at about 45,952MW at 10 a.m.—roughly 25% of the region’s entire installed capacity.

But the performance numbers were far worse for PJM’s gas plants. On Dec. 24, PJM said 32,473MW of the system’s gas capacity had been forced offline, almost 38% of the total. The region’s coal plants fared better, but 7,562MW of that capacity was offline on Dec. 24, as well. Together, gas and coal generators accounted for 87.1% of the system’s forced outages during the peak demand day—hardly a sterling performance for resources that tout their reliability.

In addition to the forced outages, PJM said, another 6,000MW of steam generation was called to operate “but was not on-line as expected per their time to start for the morning peak on Dec. 24.”[10] Officials said the vast majority were gas-fired facilities.

The problems at PJM are particularly troubling because the system’s capacity market pays generators to be ready and able to produce during such high demand events. After the polar vortex of 2014, when the system also faced massive unplanned outages, PJM enacted a penalty system to fine non-performers and use the funds to reward entities that overperform during emergency situations. Generators this winter also were required for the first time to verify “their facilities’ cold weather operating temperature limit.”[11] Improvements are clearly needed in that verification process: PJM said in its initial analysis that generators provided less than an hour’s notice, and in some cases no notice at all, for 92% of the outages during the event.[12]

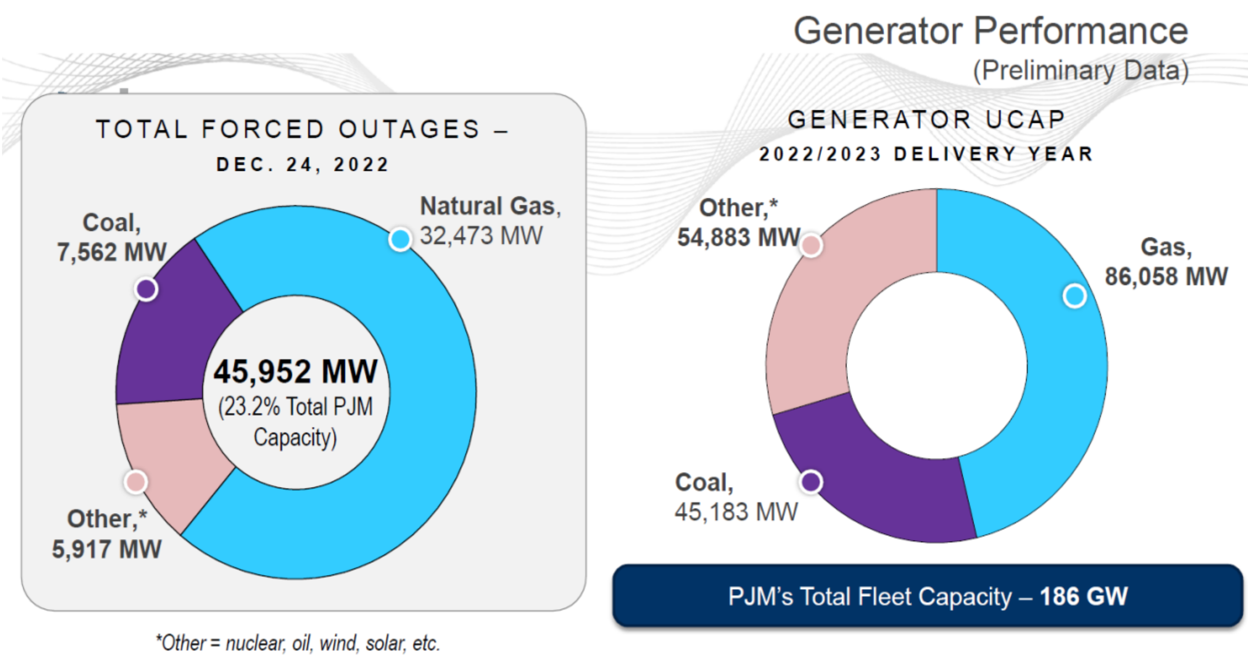
In a presentation to PJM’s market implementation committee in January, Mike Bryson, senior vice president of operations, was even more blunt: “Quite frankly … generator-forced outages were unacceptable.”[13]

[9] PJM. Winter Storm Elliott. January 11, 2023. The data in this section was taken from this PJM presentation unless otherwise noted.
[10] *Ibid*.
[11] PJM. PJM, Members Prepared To Meet Winter Electricity Demand. December 1, 2022.
[12] PJM. Winter Storm Elliott.
[13] PJM Inside Lines. PJM Operated Reliably Throughout Winter Storm Challenges. January 12, 2023.

The failures will be costly. PJM said non-performance charges linked to the December storm could total as much as $2 billion.[14] Although the exact amount of the penalties is still unclear, PJM said in a subsequent presentation that roughly 200 market participants are expected to be assessed a penalty for poor performance.[15] Some penalties are likely to be so large that PJM is proposing to spread out the payment period and has contacted "market participants that bear the most risk."[16]

These are indeed large sums, but it is not certain they will have any measurable impact on future reliability. Depending on the amounts that affected generators made in capacity payments in previous years, the penalties may simply reduce their overall return while not leading to improved performance. In addition, the power costs from the event will be paid for by PJM customers, meaning they will effectively be paying twice for the same fossil generation resources, once for the initial capacity charge that was supposed to guarantee performance and a second time to cover the cost of those resources' failures. The penalties also don't address the key issue of gas supply reliability, a problem that surfaced in every region during the storm (discussed below, in the section "Natural Gas Suppliers Stumble.")

Figure 5: PJM Gas, Coal Outages Topped 40 GW



Source: PJM.

[14] PJM. Winter Storm Elliott.
[15] PJM. Performance Assessment Interval Credit/Billing Approach, January 24, 2023.
[16] *Ibid.*

Trouble at TVA

The Tennessee Valley Authority serves 10 million people in a seven-state service territory centered around the state of Tennessee. It has been a laggard in the clean energy transition, currently securing just 3% of its capacity from wind and solar resources. Its lack of renewables made the utility's problems during the Christmas storm much more significant, since they were all linked to fossil fuels.

The utility set a new winter peak record of 33,425MW on Dec. 23 as the cold swept across its service territory. For the day, the utility generated a system-wide record of 740 gigawatt-hours (GWh) of electricity.[17]

While record-setting, the cold should have been manageable. According to the utility's latest annual report, it has 31,997MW of owned operating capacity (nuclear, gas, coal and hydro), plus firm contracts for another 3,440MW of gas and coal generation.[18] The utility also had contracts for 1,200MW of wind that almost certainly were available during Elliott's rapid push east. The total capacity of more than 36,500MW should have been sufficient for the utility to meet its peak demand.

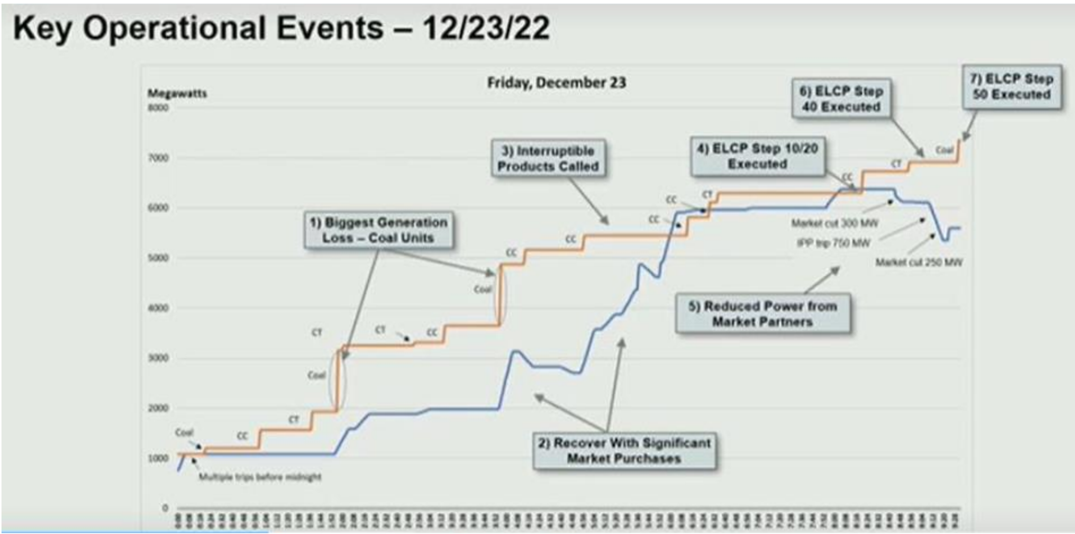
But problems across its gas and coal fleets, both owned and contracted (see Figure 6), forced the utility to institute rolling blackouts in its service territory for the first time in TVA's 94-year history.

The failures were significant. In a filing for the quarter ending Dec. 31, 2022, TVA said that 8,000MW of coal and gas generation were forced offline during the storm as a result of freezing instrumentation and other problems.[19] The outages amounted to more than 36% of the system's total available coal and gas generation, a clear indication of across-the-board reliability issues, not just problems at one or two plants.

During the utility's first-quarter earnings call, CEO Jeff Lyash tried to shift blame for the utility's capacity problems to the merchant plants TVA contracts with for power, saying they were not as "robustly designed" as the utility's own units. However, TVA also had problems internally. Three of the four coal-fired power plants that failed to produce at some point—Cumberland, Shawnee and Kingston—are TVA plants. And while the utility has been tight-lipped about the extent of the coal outages, it acknowledged that the two-unit, 2,470MW Cumberland station had significant problems during the freeze.

[17] TVA. TVA, Local Power Companies Manage Record-Setting Power Demand. December 24, 2022.
[18] TVA. Form 10-K. November 15, 2022, p. 14.
[19] TVA. Form 10-Q. January 31, 2023, p. 53.

Figure 6: TVA's Gas, Coal Outages Climbed Steadily



Source: TVA.

A number of TVA's gas plants also had problems, including the new 1,160MW combined cycle gas unit at Paradise, which the utility brought online in 2017 to replace the three-unit Paradise coal plant that it retired in stages from 2017-20. The problems at Paradise are particularly problematic for TVA since it is planning a similar coal-to-gas shift at its Cumberland plant. In the utility's post-freeze announcement of the Cumberland replacement plans, which call for the construction of a 1,450MW combined cycled gas plant at the site by 2026, Lyash said: "Replacing retired generation with a natural gas plant is the best overall solution because it's the only mature technology available today that can provide firm, dispatchable power by 2026 when the first Cumberland unit retires—dispatchable meaning TVA can turn it off and on as the system requires the power."[20]

After the utility's problems in December, it is fair to question whether the new gas facility will be as reliable as TVA claims.

TVA also touts the ability of gas-fired generation to enable the utility to reduce its off-system power purchases during high-price peak periods. However, in its December financial filing, the company acknowledged that it was forced to purchase "a significant volume of power to help meet energy needs…during the winter storm event."[21] The purchases will end up costing ratepayers $149 million, the utility said.

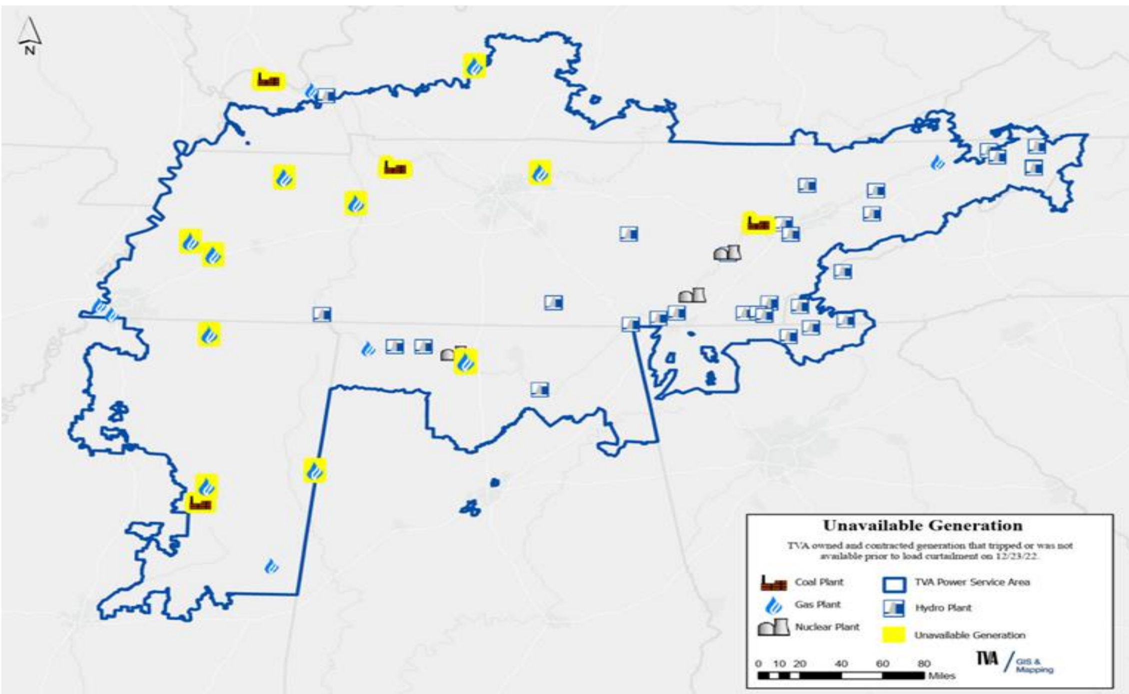
In contrast to those costs, utilities that have switched to renewable generation have been touting the savings from that transition. For example, Xcel Energy, an early adopter of wind and solar, estimates that its Midwest customers saved $1 billion from 2017-21 through its buildout of zero fuel cost

[20] TVA. TVA Retiring Cumberland, Continues Transition to Clean Energy Future. January 10, 2023.
[21] TVA. Form 10-Q. December 31, 2022, p. 54.

renewable generation and that additional savings from the 2022 Inflation Reduction Act could add another $1.4 billion to the total. [22]

Elsewhere, Florida Power and Light said its customers saved $200 million in fuel costs just in the first seven months of 2022 from its growing solar portfolio in the state.[23] Tampa Electric estimated its customers saved $90 million in annual fuel costs from its solar generation.[24]

Figure 7: TVA Coal and Gas Generation Outages



Source: TVA presentation to Kentucky legislature.

[22] Daily Energy Insider. Xcel Energy Sees $1.4B in Cost Savings Through Inflation Reduction Act. February 6, 2023.
[23] FPL. FPL Proposes Plan to Refund Customers Nearly $400 Million in Federal Corporate Tax Savings. September 23, 2022.
[24] Tampa Electric. Tampa Electric to Further Expand Renewable Energy with More Solar Projects. October 18, 2022.

Duke Forced Into Rolling Blackouts

The story at Duke's two North Carolina utilities, Duke Energy Carolina (DEC) and Duke Energy Progress (DEP), played out in much the same fashion as at its neighbors. Demand rose quickly on the evening of Dec. 23 as the storm moved in and temperatures tumbled. Demand in DEC jumped from 16,000MW at 4 p.m. to 20,000MW by 10 p.m.; DEP's demand rose from 9,000MW at 3 p.m. to almost 13,000MW at 10 p.m. The demand increases tapered for several hours but then started rising again. The system was unable to respond, requiring the utility to institute rolling blackouts across the state for the first time.

Duke officials have plotted the forced outages that ultimately prompted the blackouts, including:

- A 359MW reduction in generation capacity at its 720MW Dan River combined cycle gas plant;
- A 325MW drop-off at Unit 3 of the four-unit, 2,462MW Roxboro coal plant;
- The failure of three combustion turbines to start at its Blewett plant, keeping 51MW off the grid;
- A boiler problem at the 713MW, coal-fired Mayo plant that kept 350MW offline; and
- The failure of NTE's Kings Mountain combined cycle gas facility, an independent power producer that sells into the Duke system, which took 300MW of the facility's 513MW of capacity offline.

Kendal Bowman, Duke's state president for North Carolina, told regulators that equipment malfunctions reduced the utility's generation capacity by roughly 1,300MW beginning late on Dec. 23.[25]

Duke had plenty of other problems with its fossil fuel generation. According to data the utility presented to the North Carolina Utilities Commission after the event, 2,635MW of its other coal and gas generation were already out of service prior to the freeze, largely as a result of unplanned outages.

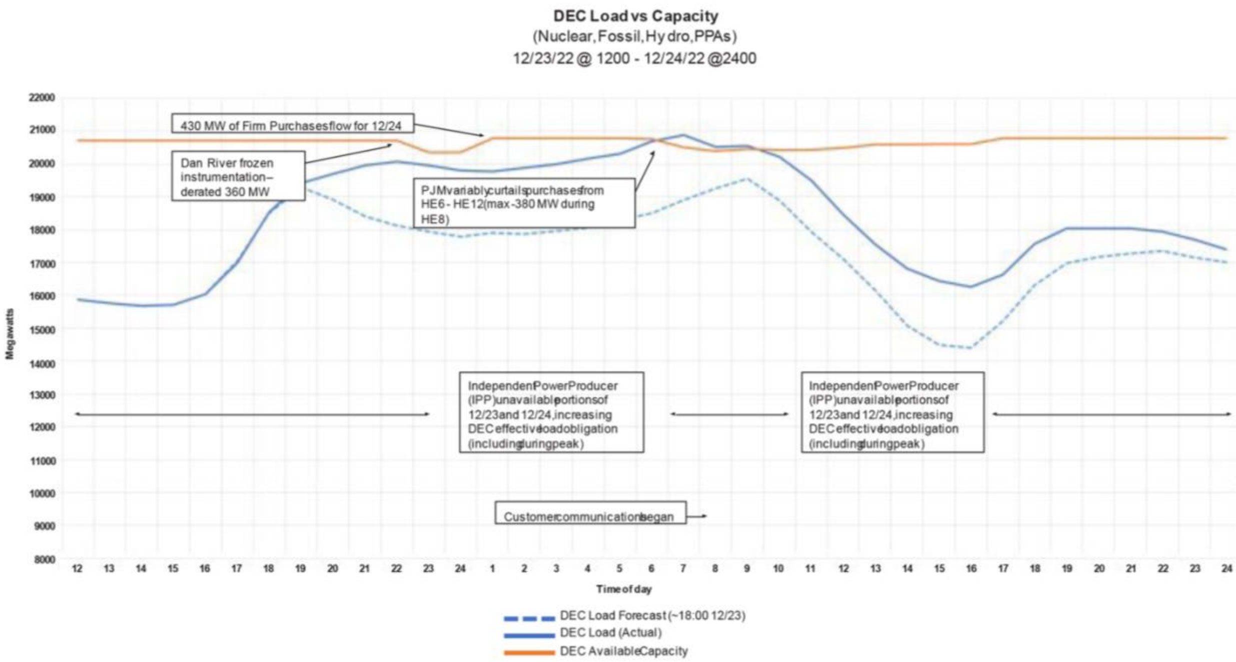
Together, at least 3,730MW of the utility's supposedly reliable gas and coal resources were unable to operate during the December freeze.

Duke has not aggressively pursued solar options in its Carolina service territory, and has sought to limit the amount of PV capacity it must bring online annually. Still, Duke officials acknowledged during their January presentation that solar generation played a key role on the morning of Dec. 24 in enabling the utility to refill its 1,400MW Bad Creek pumped storage hydro facility to prepare for peak needs later in the day.

[25] North Carolina Utilities Commission. Duke Briefing on Winter Storm Elliott. January 3, 2023.

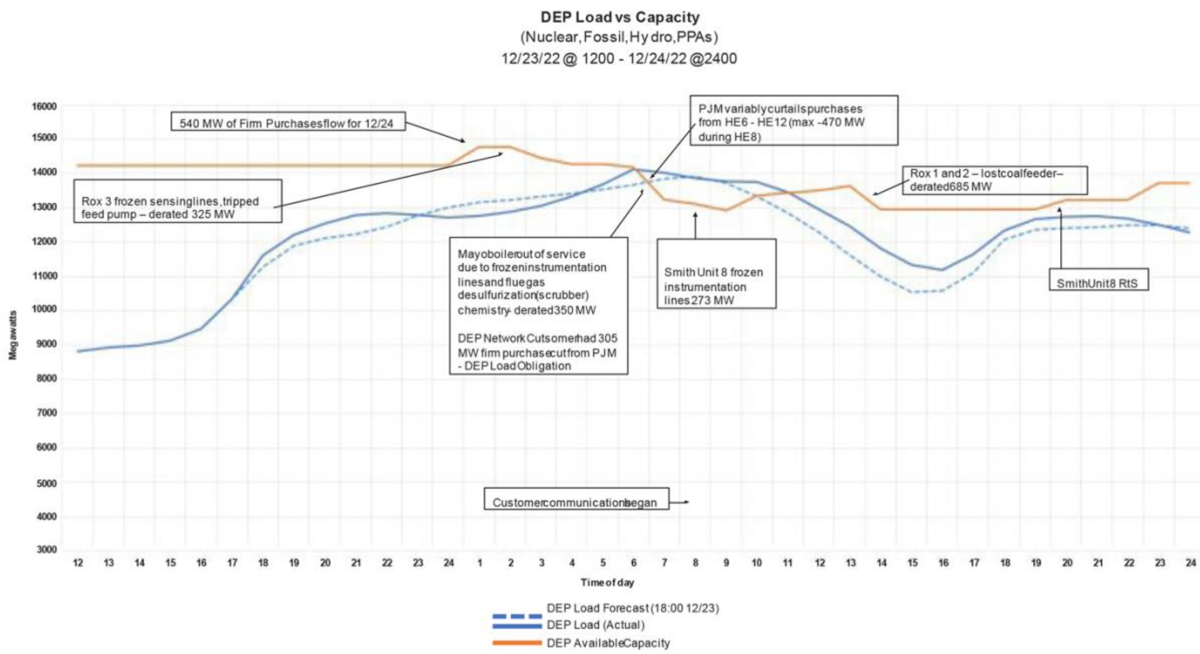
Solar itself would not have prevented Duke's rolling blackouts since they were initiated before sunrise. But paired with sufficient four-hour storage it could have eliminated or at least significantly reduced the utility's capacity shortfalls, preventing or shortening the service interruptions. In DEC's case, for example, the utility was short less than 500MW and only for three hours. DEP's shortfall (see Figure 9) was larger and lasted slightly longer, but battery storage also would have significantly reduced the size and longevity of the outages.

Figure 8: DEC's Capacity Situation



Source: Slide 21 of 35, North Carolina Utilities Commission, January 3, 2023 Briefing on Rolling Outages.

Figure 9: DEP's Capacity Situation



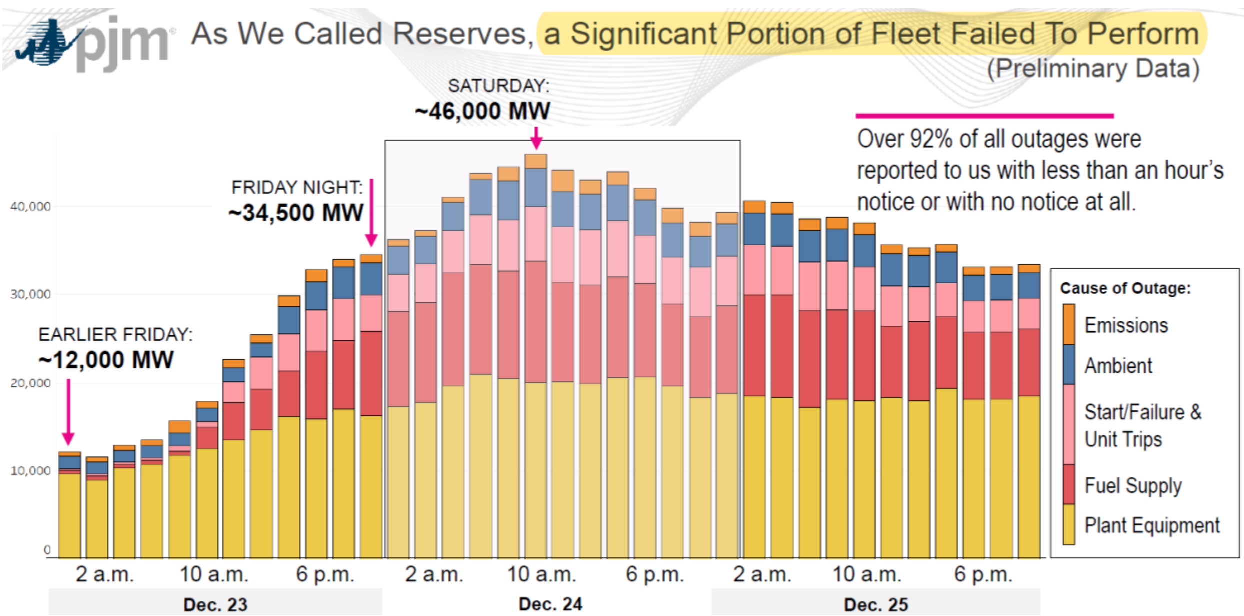
Source: Slide 22 of 35, North Carolina Utilities Commission, January 3, 2023 Briefing on Rolling Outages.

Natural Gas Suppliers Stumble

A related issue that raises serious questions about the reliability of gas-fired generation is problems with the pipeline network, which surfaced in almost all the regions hit by the Christmas freeze.

In PJM, for example, more than 10,000MW of generation had been forced offline due to fuel supply problems at the peak of the system's forced outages on Dec. 24. It is likely that most of the outages were due to gas supply problems. PJM's initial report did not break down the totals between coal and gas. But given the shortness of the event and the lack of precipitation, it is unlikely that frozen coal piles played a significant role in the forced outage total.

Figure 10: Fuel Supply Was a Big Issue in PJM



Source: PJM.

Lonnie Bellar, COO at Louisville Gas & Electric (LG&E), told Kentucky lawmakers that a significant pressure drop on the interstate Texas Gas Pipeline limited its ability to supply gas to two of its gas-fired power plants, the 689MW Cane Run combined cycle unit and the six-unit 1,074MW Trimble County combustion turbine facility.[26]

At one point during the freeze, Bellar said, this forced LG&E to cut generation at the two plants by 50 percent. The reduced generation ultimately led to rolling blackouts in the utility's service territory.

[26] WLKY. How Rolling Blackouts Happened in Kentucky, and What's Being Done to Prevent More. February 2, 2023.

"Just to be clear," he told the state legislators, "the machines were there, they were running, all we had to do is effectively turn them up if we had the pressure."[27]

The LG&E plants may have been ready to run, but the system's reliability broke down. The plants could not deliver when needed. Utilities and generators cannot shirk responsibility and shift blame to the pipelines.

Similar problems surfaced in North Carolina. In a briefing to the utility commission, Duke officials said that they were forced to cut generation at the 718MW Buck combined cycle gas plant by 178MW at 10 a.m. on Dec. 24; the reduction occurred after Duke hit its peak demand, but still during the period when it was restoring customers and reserves were extremely tight. Duke blamed low pressure on the Transco pipeline that serves much of the utility's gas-fired generation. Like LG&E, the output from the Buck facility almost certainly would have been available if sufficient gas had been supplied; the plant's average capacity factor has been more than 70% for the past seven years. But if one piece of the gas system isn't able to deliver when needed, then the whole system simply cannot be considered reliable.

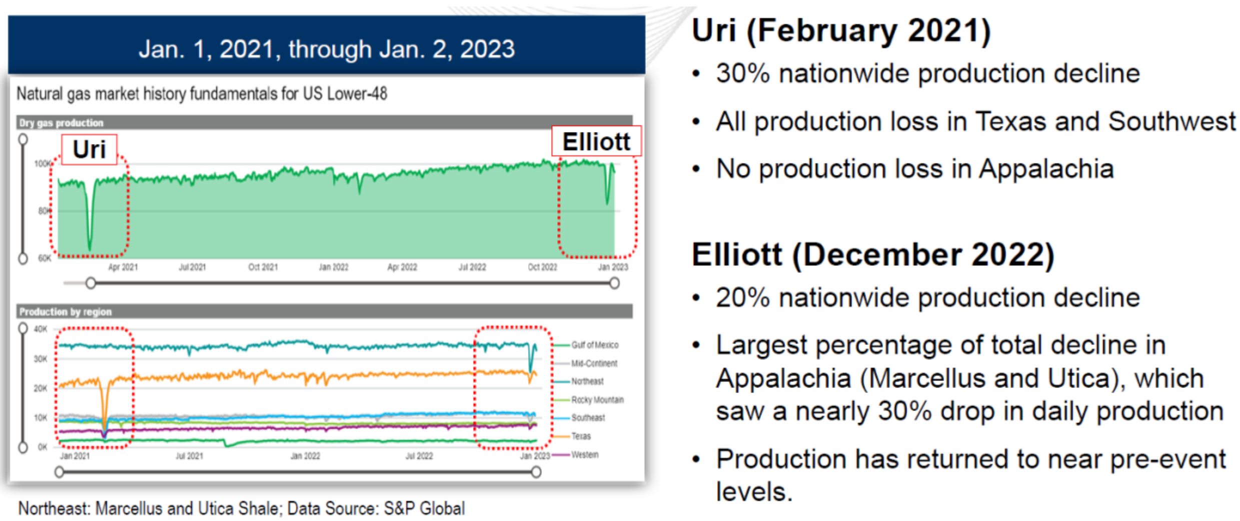
MISO staff also highlighted "gas supply challenges" as one of the problems the system faced during the Christmas freeze. The challenges "contributed to increased unplanned outages, particularly in the afternoon, that pushed MISO into emergency procedures."[28]

Fuel availability was also a problem for gas plants in Texas, despite the winterization that was supposed to take place after the 2021 debacle. At least 25 gas-fired units were offline at some point during the event (Dec. 22-24) due to fuel-related problems. A significant number of other gas plants also tripped offline during the freeze, but simply cited "other" as the reason for the outage. ERCOT's coal plants also had fuel supply problems, continuing a year-long issue for several of the system's coal-fired units.

Overall, the fuel availability problems highlight the interconnected nature of the gas supply and distribution and the power production sectors—power producers aren't reliable unless suppliers are reliable, as well. But the linkages have largely been ignored, effectively enabling gas-fired power producers to claim a level of reliability that they can't deliver during extreme weather events.

[27] *Ibid.*
[28] MISO. Operations Report. February 13, 2023.

Figure 11: Northeast Gas Production Hit Hard By Elliott



Source: PJM.

Conclusion

The problems encountered across the central and eastern U.S. during Winter Storm Elliott show that it is time for a more honest discussion about the reliability of the electric power sector's thermal generation resources. Coal- and gas-fired resources are generally reliable resources, but they cannot be assumed to be 100% dispatchable. Their performance in December shows how unreliable they can be exactly when they are needed most. The increasingly troublesome record of performance needs to be accounted for in utility and transmission system planning efforts.

Our recommendations include:

- A joint effort by industry and FERC to address performance issues in the natural gas supply sector. If the supply cannot be guaranteed, then the generation resource certainly cannot be considered completely reliable either.
- Better integration of battery storage in utility and regional resource planning efforts. Storage is a cost-effective means of bridging early morning winter peaks until solar resources kick in, just as it is an option for flattening late afternoon peaks in the summer months.
- Ensuring that existing market structures, particularly in PJM, do not provide incentives for poor-performing fossil resources to remain operational and collect capacity payments, even at the risk of occasionally being hit with a penalty for failing to provide power when needed.
- Development of better capacity accreditation methods for fossil fuels, which traditionally have been considered as always-available resources. Factoring in past performance during extreme events (the 2014 polar vortex and the 2022 December freeze) would provide operators with a more realistic assessment of potentially available capacity.

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